Comparative Analysis of Digital Dentistry and Conventional Techniques in Implantology a Systematic Review of Clinical Success and Patient Outcomes

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Abstract

Objectives: To compare digital dentistry with conventional techniques in implantology based on clinical success rate, accuracy, patient satisfaction, and overall treatment outcomes.

Methods: A total of 412 pertinent publications were found after a comprehensive search across four databases. 68 full-text publications were examined after duplicates were eliminated using Rayyan QCRI and relevance was checked; seven studies finally satisfied the requirements for inclusion.

Results: We included seven studies with a total of 449 patients, 483 dental implants, and 196 (43.6%) were males. The majority of the studies revealed that digital workflows always had higher patient satisfaction with the increased comfort, reduced chair time, and better procedural efficiency. Though there were some reports on no distinct preference, in general, digital impressions were preferred for being less invasive and convenient. Clinical advantages included the improved accuracy of the digital method, smooth workflow, and fewer visits by the patient, especially in single-implant restorations and full-arch immediate loading cases. However, conventional techniques remained a good alternative with comparable outcomes in certain contexts.

Conclusion: Digital workflows enhance implantology with improved accuracy, efficiency, and patient satisfaction, making them valuable in modern dentistry. While conventional methods remain reliable, digital techniques are particularly beneficial for complex, precision-demanding cases. Future research should focus on long-term outcomes, cost-effectiveness, and increasing accessibility to digital tools, ensuring continued advancements in patient care.

Keywords: *Digital dentistry; Conventional impressions; Implants; Patients' satisfactions; clinical outcomes Systematic review.*

Introduction

Digital implant scans are still relatively new in the field of implant dentistry, even though digital planning and computer-guided surgery are standard practices [1]. Digital scans are a crucial component of the digital workflow used to fabricate the final implant prosthesis [2]. Standard Tesselation Language files are created by digital scans using intraoral scanners and are utilized to build either definitive or implant-supported interim prostheses [3]. In order to create the "virtual patient," the STL files can also be superimposed with datasets from facial scanners or cone beam computed tomography (CBCT) scans. This approach results in a thorough diagnosis, treatment planning, and patient communication [4].

Currently, multiple-unit fixed dental prostheses (MFDPs) are produced using conventional methods, which are successful and widely used [5]. To prevent mistakes that could compromise the correctness of the final outcome, they do, however, necessitate a high level of workflow consistency. Making and processing impressions, producing and storing casts, and treating materials appropriately throughout the production phase are all crucial processes. Inadequate impression tray preparation and selection, restrictions in the flow and hydrophilicity of the impression material, ripping and deformation of the impression during removal [6], or incorrect handling and pouring techniques and timing can all result in errors [7].

The digital workflow for dental prosthesis fabrication has become increasingly popular in recent years due to the advancement of computer-aided design and computer-aided manufacturing (CAD-CAM) technologies. This is because it eliminates the disadvantages of conventional techniques, at least during the production phase, and requires fewer clinical appointments, quality-controlled materials, preclinical optimization of the MFDP shape [8], and a higher degree of standardization. Only possible mistakes in the manufacturing stage can profit from the use of CAD-CAM if the digital workflow begins with the digitization of casts made from traditional impressions. Previous research has examined their efficacy by examining the fit of prosthesis made using digital technologies [9].

The field of implantology has evolved significantly with the introduction of digital dentistry, which encompasses tools like computer-aided design and manufacturing, cone beam computed tomography, and intraoral scanners. These technologies aim to enhance the precision, efficiency, and overall outcomes of dental implant procedures. However, conventional techniques remain widely practiced, and their reliability and cost-effectiveness make them a preferred choice in certain clinical settings.

The comparison between the digital and traditional methods would, therefore, be required to elucidate the various advantages, limitations, and implications that each has to clinical success and patient outcome. This systematic review was needed to bring together available evidence, identify knowledge gaps, and present a comprehensive understanding for clinicians to guide their practice.

This systematic review aims to compare digital dentistry with conventional techniques in implantology based on clinical success rate, accuracy, patient satisfaction, and overall treatment outcome. The study will establish whether one of the approaches yields better results or if they are comparable for specific clinical scenarios, supported by evidence-based recommendations for dental practitioners.

Methods

Search strategy

The PRISMA and GATHER criteria were adhered to in the systematic review. To locate pertinent research on the outcomes digital dentistry with conventional techniques in implantology ms, a comprehensive search was carried out. Four electronic databases were searched by the reviewers: SCOPUS, Web of Science, Cochrane, and PubMed. Included studies were within the last 5 years between 2020-2024. We eliminated any duplicates and uploaded all of the abstracts and titles that we could find using electronic searches into Rayyan. After that, all of the study texts that met the requirements for inclusion based on the abstract or title were gathered for a thorough examination. Two reviewers independently assessed the extracted papers' suitability and discussed any discrepancies.

Study population—selection

The PICO (Population, Intervention, Comparison, and Outcome) factors were implemented as inclusion criteria for our review: (i) Population: Patients undergoing dental implant procedures, (ii) Intervention: Digital workflows, including tools like CAD/CAM, CBCT, and intraoral scanners, used for implant planning, impressions, and placement, (iii) Comparator: Conventional techniques, (iv) Outcome: Clinical success, patient satisfaction, procedural efficiency.

Data extraction

Data from studies that satisfied the inclusion requirements were extracted by two objective reviewers using a predetermined and uniform methodology. The following information was retrieved and recorded: (i) First author (ii) Year of publication, (iii) Study design, (iv) Participants' number, (v) Age, (vi) Gender, (vii) Follow-up period (in months), (viii) Patients outcomes, (ix) Clinical outcomes.

Results

The specific search strategy produced 412 publications, as shown in **Figure 1.** After duplicate removals (n=231), a total of 181 trials were assessed for title and abstract. Thereafter, 113 did not meet the eligibility criteria, leaving only 68 full-text articles to be fully appraised. Of these, 7 met the eligibility criteria with evidence synthesis for analysis.
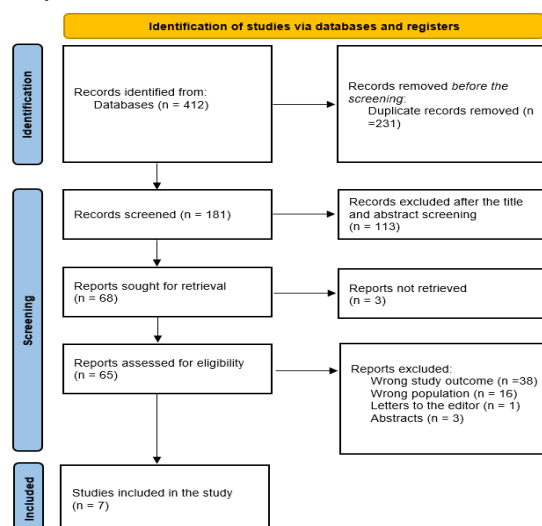

Figure (1): PRISMA flowchart [10].

Sociodemographic and clinical outcomes

We included seven studies with a total of 449 patients, 483 dental implants, and 196 (43.6%) were males. Regarding study designs, all studies were case-controls [12-17]. Two studies were implemented in The USA [12, 17], one in India [13], one in Brazil [14], one in Italy [15], and one in Spain [16].

Clinical outcomes

The follow-up period ranged from 3 [16] to 48 months [12]. The main outcomes underlined the clinical advantages of digital workflows in implantology: the higher accuracy of digital methods in implant positioning and fabrication, which is likely to be transferred into the improved treatment outcome and procedural streamlining; they also effectively reduced time consumption of the workflow, including fewer patient visits, while maintaining or outperforming traditional techniques. In specific indications, such as full-arch immediate loading or single-implant restorations, the results from digital approaches were excellent and often comparable with traditional methods. However, both methods were found to offer significant clinical success, with the choice often influenced by procedural requirements and available resources [11-17].

Patients' reports

The patients' reports outlined different levels of satisfaction and preferences for digital workflows over traditional techniques. Most studies indicated that digital workflows were associated with higher patient satisfaction, especially because of their precision, reduced chair time, and less invasive procedures [11, 12, 15, 16]. However, some patients did not show a clear preference since both techniques appeared to work for them [13, 14]. Besides, many digital impressions were highly recommended for others as being less disagreeable, pointing out advantages related to comfort and convenience [11-17]. Overall, digital workflows often reported superior rates of acceptance among dental patients, though traditional approaches could be valued for reliability in some contexts, reducing anxiety and procedural simplicity.

Table (1): Outcome measures of the included studies

Study ID	Study design	Country	Sociodemographic	Follow-up (months)	Patients' reports	Clinical outcomes
Corsalini et al., 2024 [11]	RCT	Italy	N: 60 Implants: 72 Males: 27 (45%)	06-Dec	Compared to the traditional workflow, patient satisfaction was better in the digital one.	The findings of this study demonstrate that digital workflows are more accurate and patient-tolerant than traditional methods.
Beck et al., 2024 [12]	RCT	Austria	N: 30 Implants: 30 Mean age: 46.5 Males: 14 (46.7%)	48	Although patients would more frequently suggest the digital impression to friends, there was no obvious preference for an impression technique.	Compared to the traditional workflow, the digital workflow streamlines the implant crown creation process by cutting down on processes, perhaps leading to increased accuracy.
De Angelis et al., 2023 [13]	Retrospective cohort	Italy	N: 150 Implants: 150	24	NR	The current study's findings indicate that digital impressions can be a good substitute for traditional procedures in the implementation of full-arch immediate loading prostheses.

			Mean age: 55 Males: 75 (50%)			
Lee et al., 2022 [14]	RCT	USA	N: 30 Implants: 30 Mean age: 53.1 Males: 15 (50%)	24	NR	For restorations supported by a single implant, the digital scanning method outperformed the traditional impression method in terms of efficiency. The precision of CAD-CAM implant casts and digital scans was on par with that of gypsum casts and traditional impressions.
Kunavisarut et al., 2022 [15]	RCT	Thailand	N: 40	12	When it came to implant rehabilitation of single-tooth gaps in posterior sites with monolithic implant crowns, both fully digital and traditional methods offered high	NR

			Implants: 51 Mean age: 50.7 Males: 16 (40%)		levels of patient satisfaction.	
Pereira et al., 2022 [16]	RCT	USA	N: 17 Implants: 28 Males: 8 (47%)	NM	Compared to traditional impressions, digital impressions had a greater patient acceptance rate.	Compared to traditional impressions, digital impressions required less chair time.
De Angelis et al., 2020	Retrospective cohort	Italy	N: 122 Implants: 122 Mean age: 58.3 Males: 41 (33.6%)	3	In terms of anxiety, convenience, taste, nausea, discomfort, and breathing difficulties, the digital workflow showed improved results on the VAS scale (p < 0.0001).	Both the mean time for the digital workflow and the number of necessary trips were significantly decreased.

*NR=Not-reporte

Discussion

This systematic review compares digital and conventional techniques in implantology, providing an overview of the literature on how these approaches may affect clinical success and patient outcomes. Digital workflows have transformed implantology by introducing tools that enhance precision, efficiency, and patient satisfaction. The studies reviewed here would seem to indicate that digital methods offer greater procedural accuracy, a reduction in chair time, and fewer patient visits with comparable or superior clinical outcomes. Yet the findings also underscore that conventional methods can be just as effective and reliable in resource-limited settings or where digital technology is not available.

Papaspyridakos et al. reported that based mostly on in vitro research, digital scans seem to provide 3D precision that is comparable to traditional implant impressions [18]. **Russo et al.** also found that digital technology provide a dependable substitute for traditional methods in the production of three-unit fixed partial dentures supported by teeth or implants [19]. In the same line, **Chochlidakis et al.** found that the marginal disparities between dental restorations made using the digital impression technique and those made using the traditional impression approach were statistically comparable. Similar

findings were seen for the internal and marginal disagreement in the traditional and digital groups with respect to "pressing" and CAD-CAM fabrication procedures [20].

The accuracy and fit prediction of fixed partial prosthesis may have increased with the advent of CAD-CAM technologies [30]. There is, however, little proof that MFDPs created using digital methods marginally fit those created using the traditional method. In one or more steps throughout the manufacturing and processing of impressions, the manufacture and storage of casts, and the selection and handling of materials during the production phase, a number of procedure-, material-, or operator-dependent variables may cause a marginal disagreement [21].

The use of digital workflows in implantology is likely to be revolutionary in changing clinical practice. High accuracy and reduced time of the procedures can improve treatment predictability and patient satisfaction. Full-arch restorations and immediate loading are among such indications where accuracy is required. However, clinicians need to weigh the advantages of digital technology against the initial cost of investment and steep learning curve that come with its use. With improved availability and affordability, the integration of these tools into routine practice will continue to become more common, benefiting patient care.

Strengths

The main strength of this review is that it provides an in-depth analysis of several studies that compare digital and conventional techniques. It pools data from various clinical settings and therefore provides a wide understanding of the strengths and weaknesses of each approach. In addition, the inclusion of patient-reported outcomes offers valuable insights into the subjective experiences of patients, which are often neglected in technical assessments.

Limitations

Several limitations should be recognized: the heterogeneity of the included studies in terms of study design, follow-up periods, and sample sizes that may affect the generalizability of the findings; further, some did not report detailed sociodemographic data or long-term outcomes limiting the assessment of sustained benefits of each technique. The potential for publication bias, with studies favoring digital workflows being more likely to be published, should also be considered.

Conclusion

Digital workflows in implantology have great advantages concerning accuracy, efficiency, and patient satisfaction, hence forming a worthy addition to modern dental practice. Although conventional techniques are still effective and widely used, digital methods are especially indicated in complex cases that demand high precision. Further research is needed regarding long-term clinical outcomes, cost-effectiveness, and how to make digital tools more accessible to practitioners worldwide. By addressing these aspects, the field can continue to advance, ensuring optimal care for patients undergoing dental implant procedures.

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